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Study of the Density and Viscosity of a Suspension in Potassium Sulfate Conversion

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ABSTRACT:
The results of investigations on the study of changes in the rheological properties of solutions, suspensions and pulps formed during the conversion of potassium chloride from sylvinites of the Tyubegatan deposit with sodium sulfate are presented.It is shown that the density and viscosity decrease with increasing temperature from 20 to 80°C and after the first stage of isolation of glaserite is 1.426-1.286 g/cm^3 and 5.325-2.618 cps, after the second stage of introducing potassium chloride into the solution of glaserite 1.581-1.476 g/cm^3 and 6.254-3.080 cps, respectively.

KEYWORDS: *Potassium sulfate, conversion, glazerite, suspension, potassium chloride.*

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I. Introduction

The modern progress of agriculture, along with the introduction of new high-yielding varieties, an increase in the level of mechanization of field work and irrigation, is largely determined by the degree of its chemicalization and, above all, the use of mineral fertilizers, growth and development stimulants, and chemical plant protection products [1].

The production of mineral fertilizers in the Republic is developing at an accelerated pace. This development has not only a quantitative, but also a qualitative side: the raw material base is expanding, technology and equipment are being improved, the assortment is increasing and the quality of mineral fertilizers is increasing. During the years of independence, the problem of providing phosphorus plants with their own phosphorites from the Central Kyzylkum deposit has been solved. With the launch of the second stage of the potash fertilizer plant, the Republic fully provides agriculture with its own potash fertilizers [2].

However, the intensive introduction of advanced technologies for growing crops, the use of capillary fertilizer systems has increased the demand for chlorine-free potash fertilizers and, in particular, for potassium sulfate. Potassium sulphate is primarily used for chlorine sensitive crops and is used for a variety of crops and soil types. The production of potassium sulfate by converting potassium chloride with sodium sulfate is the most acceptable way. Previously, studies were carried out on the conversion of potassium chloride with the mirabilite of the Tumruk deposit, the rheological properties of solutions were determined, and the main parameters of the technological process were established [3-5].

II. RESULTS AND DISCUSSION

A longitudinal study of the density and viscosity of all stages of the conversion of potassium sulfate was carried out. The viscosity of the solutions was determined on a VPZh-2 viscometer. The density was determined by the pycnometric method.

Table IDensity of glaserite suspension in the first stage before conversion

Temperature,°C	Stage	Conversiontime, min.	Density, at temperature (g/cm^3)
20	I	0	1.385
40	I	0	1.382
60	I	0	1.29
80	I	0	1.28

The fine aggregate which is used in this study is foundry sand. According to IS383-1970 the aggregate infiltrating 4.75 mm sieve and retaining of 150 micron have the specific gravity and fineness modulus of 2.47 and 3.19 respectively.

TABLE II Viscosity of glaserite suspension in the first stage before conversion

Temperature,°C	Stage	Conversiontime, min.	Viscosity, attemperature (cps)
20	I	0	2.799
40	I	0	2.275
60	I	0	1.866
80	I	0	0.606

Experiments to determine the density and viscosity of solutions by conversion sections were carried out at temperatures of 20, 40, 60, 80°C. The results of the research are shown in the tables.

The density of the suspension with increasing temperature in the range of 20-80°C decrease. Prior to the start of the conversion of the first stage, the density of the suspension at temperatures from 20 to 80°C is 1.385 and 1.28 g/cm^3, respectively. Such a large density range shows that with increasing temperature, the solubility of the components of the raw material increases. Analyzing these data, it can be assumed that the temperature of the first conversion stage plays a key role.

Further studies were carried out to determine the viscosity of the first stage before conversion at temperatures of 20 - 80°C.

The research results show that with increasing temperature, the viscosities of suspensions are significantly reduced. Prior to the conversion of the first stage, the viscosity of the suspension is at temperatures from 20 to 100°C 2.799 and 0.606 centipoise, respectively. The resulting viscosity data, as well as density, shows a significant effect of temperature on the properties of suspensions of the first stage of conversion.

The rheological properties were investigated after the first conversion stage. The results of studies of the density of suspensions are shown in table 2, where one can observe a decrease in the density of suspensions with an increase in temperatures from 20 to 80°C from 1.426 to 1.286 g/cm^3.

Comparing the density before and after the conversion of the first stage shows an increase in density at the same temperatures. For example, at 20°C, the density of the suspension before and after conversion is 1.385 and 1.426 g/cm^3, respectively; at a temperature of 40°C, respectively, 1.382 and 1.383 g/cm^3; at a temperature of 60°C, respectively, 1.29 and 1.338 g/cm^3; at a temperature of 80°C, respectively, 1.280 and 1.286 g/cm^3. The largest difference in density is observed at 60°C. This is one of the factors why we took the temperature of the first stage of the conversion of 60°C.

TABLE III Density of glaserite suspension at the first stage after conversion

Temperature,°C	Stage	Conversiontime, min.	Density, at temperature (g/cm^3)
20	I	60	1.426
40	I	60	1.383
60	I	60	1.338
80	I	60	1.286

TABLE IV Viscosity of glaserite suspension at the first stage after conversion

Temperature,°C	Stage	Conversiontime, min.	Viscosity, attemperature (cps)
20	I	60	5.325
40	I	60	3.415
60	I	60	2.915
80	I	60	2.618

Further studies were carried out to study the viscosity of the suspensions after the first stage, depending on the temperature in the range of 20-80°C. The results of the studies showed that with increasing temperature, the viscosities of suspensions are significantly reduced.

The viscosities of the suspensions after the conversion of the first stage are reduced to a very large extent. Comparing the viscosities before and after the conversion of the first stage shows an increase in viscosity after the conversion. For example, at 20°C, the slurry viscosity before and after conversion is 2.799 and 5.325 cps, respectively; at a temperature of 40°C, respectively, 2.275 and 3.415 cps; at a temperature of 60°C, respectively,

1.866 and 2.915 cps; and at a temperature of 80°C, respectively, 0.606 and 2.618 cps. The greatest difference in viscosity is observed at 20°C.

Experiments were carried out to study the density of suspensions before conversion after adding additional potassium chloride.

The density of the suspension of the second stage before conversion, after adding additional potassium chloride, decreases with increasing temperature. Thus, at 20°C, the densities of the suspensions before and after the addition of potassium chloride during conversion are, respectively, 1.426 and 1.462 g/cm^3; at a temperature of 40°C, respectively, 1.383 and 1.460 g/cm^3; at a temperature of 60°C, respectively, 1.338 and 1.386 g/cm^3; and at a temperature of 80°C, respectively, 1.286 and 1.378 g/cm^3. The largest difference in density is observed at 80°C.

TABLE V Densities of suspensions of the stage of obtaining potassium sulfate before conversion, after adding additional potassium chloride

Temperature,°C	Stage	Conversiontime, min.	Density, g/cm^3.
20	II	0	1.462
40	II	0	1,460
60	II	0	1.386
80	II	0	1.378

TABLE VI Slurry viscosities of the potassium sulfate production stage before conversion after adding additional potassium chloride

Temperature,°C	Stage	Conversiontime, min.	Viscosity, cps
20	II	0	4.788
40	II	0	4.135
60	II	0	3.014
80	II	0	2.361

If we compare the densities before and after the first stage and before the conversion in the second stage, after the addition of additional potassium chloride, the slurry densities increase with increasing conversion time. For example, at 20° C., the slurry densities by conversion steps are 1.385; 1.426 and 1.462 g/cm^3.

In parallel with the study of the density of suspensions of the second stage before conversion, after the addition of additional potassium chloride, the viscosities of the suspensions were studied.

As the temperature rises, the viscosities of suspensions decrease significantly. If we compare the slurry viscosities of the second stage before conversion, after the addition of additional potassium chloride, with the slurry viscosity after the first stage, the slurry viscosities in the second stage, before conversion after the addition of additional potassium chloride, the changes are less significant. This can be seen when comparing both stages of the conversion. For example, at a temperature of 20°C and 80°C, the viscosities of the suspensions after the first stage are 5.325 and 2.618 cps, which are greater than the viscosities of the suspensions of the second stage before conversion, after adding additional potassium chloride, and are 4.788 and 2.361 cps. At temperatures of 40°C and 60°C, the slurry viscosities after the first stage are 3.415 and 2.915 cps, which are less than the slurry viscosities of the second stage before conversion, after adding additional potassium chloride.

Studies were carried out to determine the rheological properties (density and viscosity) of suspensions of the second stage after conversion. The density of the suspensions with increasing temperature in the range of 20-80°C decrease. For example, after the second conversion stage, the densities of the suspensions at temperatures of 20 and 80°C are 1.581 and 1.476 g/cm^3, respectively. Slurry density data after the second conversion step are shown below.

TABLE VII Slurry Density of the Potassium Sulfate Production Stage

Temperature,°C	Stage	Conversiontime, min.	Density, g/cm^3
20	II	60	1.581
40	II	60	1.572
60	II	60	1.496
80	II	60	1.476

TABLE VIII Slurry Viscosity of the Potassium Sulfate Production Stage

Temperature,°C	Stage	Conversiontime, min.	Viscosity, cps
20	II	60	6.254
40	II	60	4.573
60	II	60	3.920
80	II	60	3.080

The density of suspensions of the second stage, after conversion, decreases with increasing temperature in the range of 20-80°C. Before the start of the conversion of the second stage, after the addition of additional potassium chloride, the densities of the suspensions at temperatures of 20 and 80°C are 1.462 and 1.378 g/cm^3 respectively. And after conversion 1.581 and 1.476 g/cm^3. If we compare the densities before and after conversion at the same temperatures, we can the completetransition of potassium chloride and glaserite to potassium sulfate.

Density studies show that from the beginning of the experiment until the end of the experiment, the density of the suspensions increases. For example, in the sequence of steps, the densities of the suspensions at 20°C are respectively 1.385, 1.426, 1.462 and 1.581 g/cm^3; at a temperature of 40°C, respectively, 1.382, 1.383, 1.460 and 1, 572 g/cm^3.; at a temperature of 60°C, respectively, 1.290, 1.338, 1.386 and 1.496 g/cm^3; and at a temperature of 80°C, respectively, 1.280, 1.286, 1.378 and 1.476 g/cm^3.

Further studies were carried out to determine the viscosity of the suspensions after the conversion in the second stage at temperatures in the range of 20-80°C. Comparing the viscosities before and after conversion in the second stage, one can see an increase in viscosity after conversion. For example, at 20°C, the viscosities of the suspensions before and after conversion are 4.788 and 6.254 cps, respectively; at a temperature of 40°C, respectively, 4.135 and 4.573 cps; at a temperature of 60°C, respectively, 3.014 and 3.920 cps; and at a temperature of 80°C, respectively, 2.360 and 3.080 cps. If we compare the viscosities before and after conversion at the same temperatures, we can see an increase in the viscosity of the suspensions. Viscosity studies show that from the beginning of the experiment to the end of the slurry viscosities increase. For example, in the sequence of stages, the viscosities of the suspensions are at a temperature of 20°C, respectively, 2.799, 5.325, 4.788 and 6.254 cps; at a temperature of 40°C, respectively, 2.275, 3.415, 4.135 and 4.573 cps; at a temperature of 60°C, respectively, 1.866 - 2.915 - 3.014 and 3.920 cps; and at a temperature of 80°C, respectively, 0.606, 2.618, 2.361 and 3.080 g/cm^3.

III. CONCLUSION

- Thus, the results of studies onstudy of the density and viscosity of suspensions during the onversion of potassium chlorideindicate the feasibility of the technological process and the possibility of obtaining commercial potassium sulfateThespecimenswith5%ofsodiumsilicateachieved the desired design strength of 31.15 N/mm^2.

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